



Demo 4: Storm management

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Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

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Citation (APA):
Detlefsen, N. (Author), Gøttig, A. (Author), Cutululis, N. A. (Author), & Sørensen, P. E. (Author). (2011). Demo 4: Storm management. Sound/Visual production (digital)

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DEMO4: STORM MANAGEMENT

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Demo 4 STORM MANAGEMENT (Leader: Energinet)

Main objective

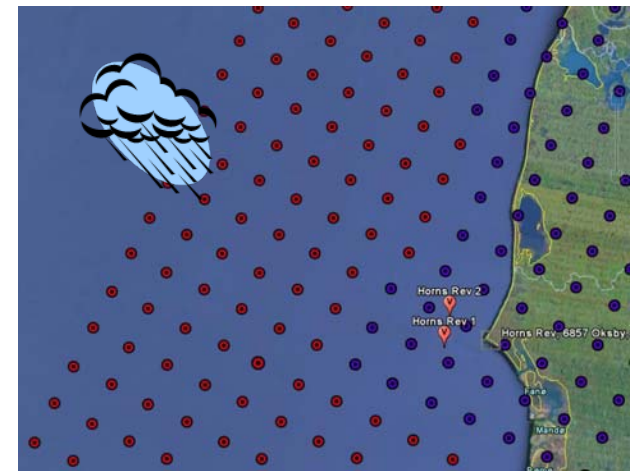
- Demonstrate shut down of wind farms under stormy conditions without jeopardizing safety of the system

Approach

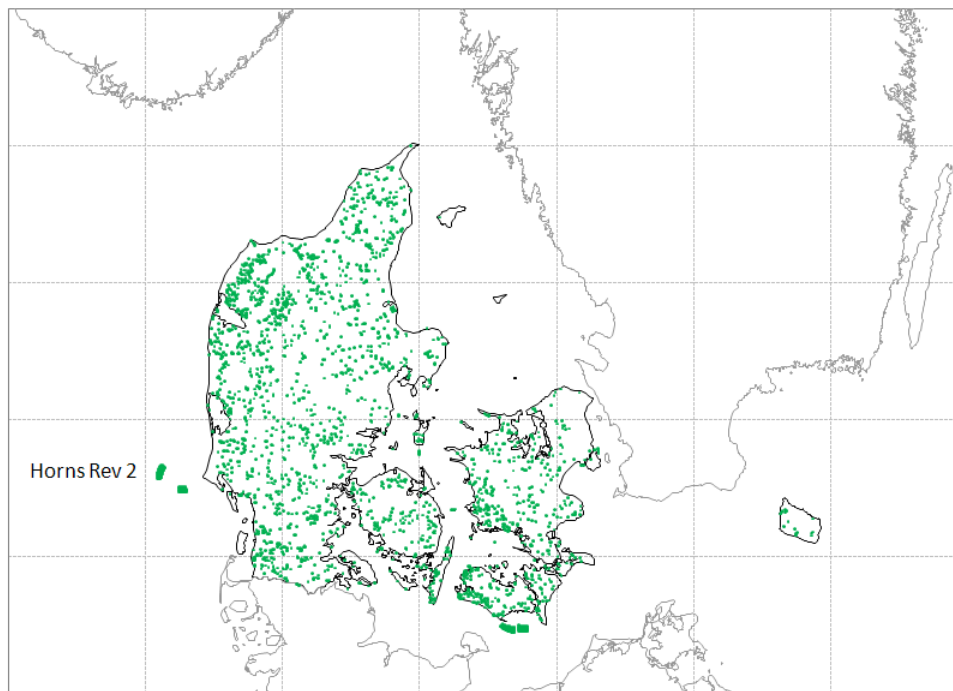
- Horns Rev 2 (200MW)
- Flexible turbine control
- Storm front forecasts
- Investigate cost of changed production associated with the planned down regulation
- Coordinate wind farm control with HVDC interconnector control and with hydro power plant operation

Wind power

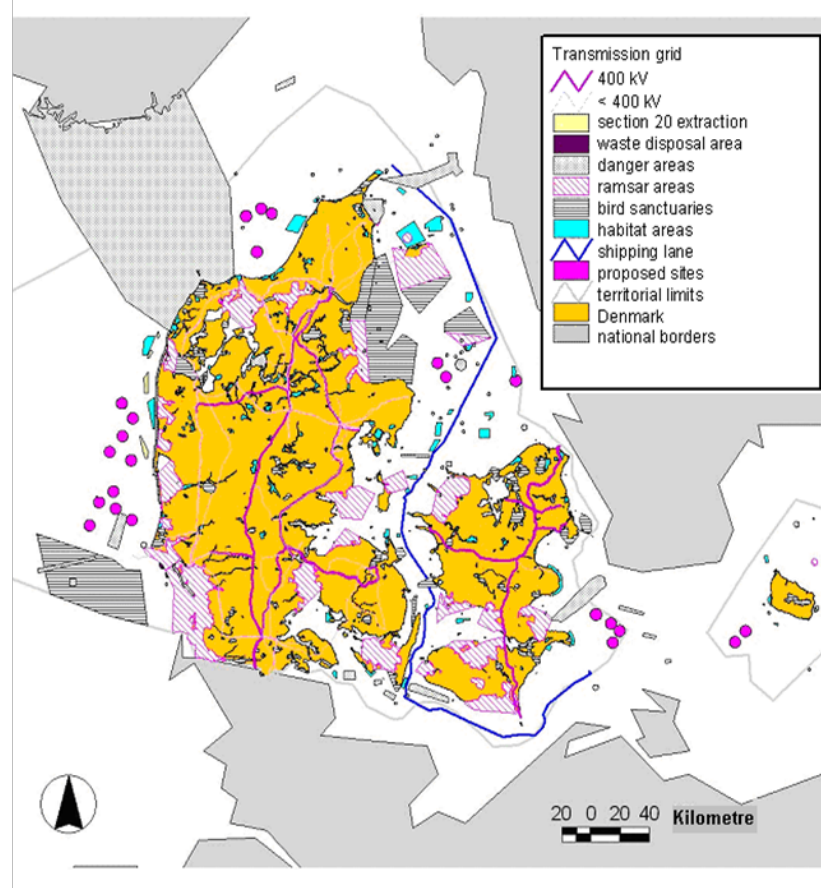
Hydro power



Present wind turbines in Denmark



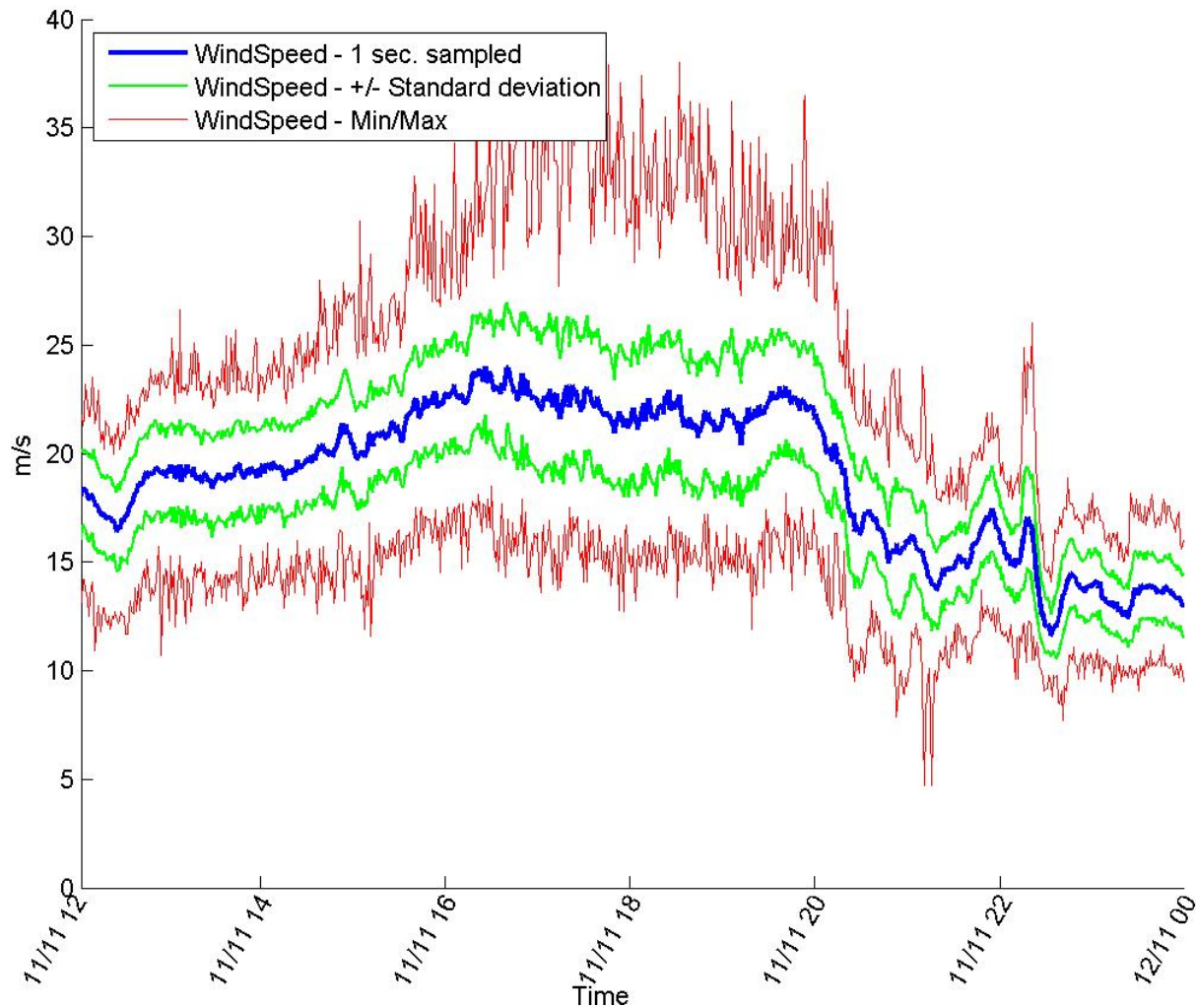
Possible offshore wind plants in Denmark (23 x 200 MW)



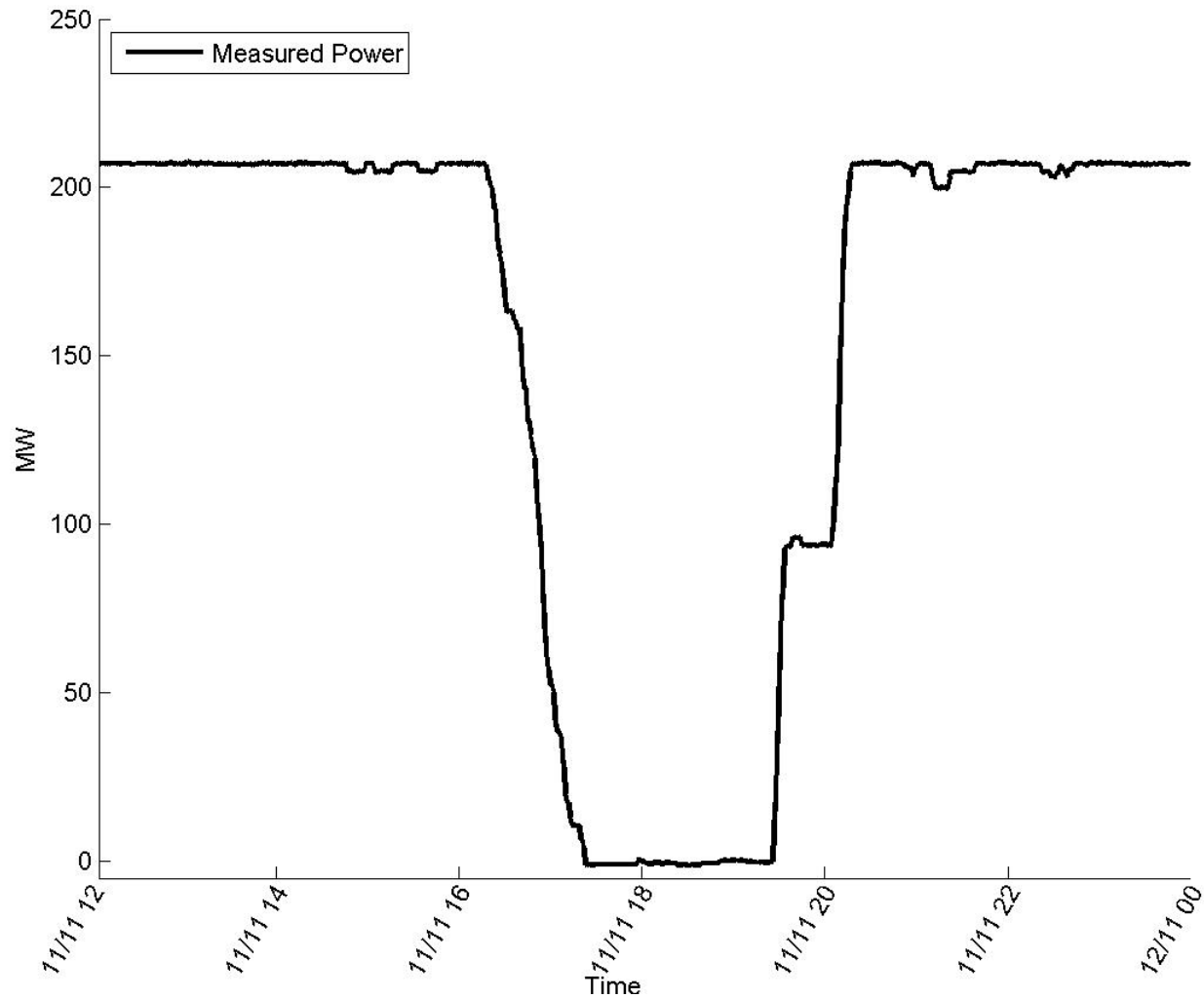
Strategies

- **Two possible strategies:**
 - Manual control
 - Automatic control
- **Manual control involves:**
 - Wind speed forecasting
 - Wind power forecasting
 - System imbalance forecasting
 - Regulating power
- **Automatic control involves:**
 - New controller in the turbines
 - Automatic imbalance control

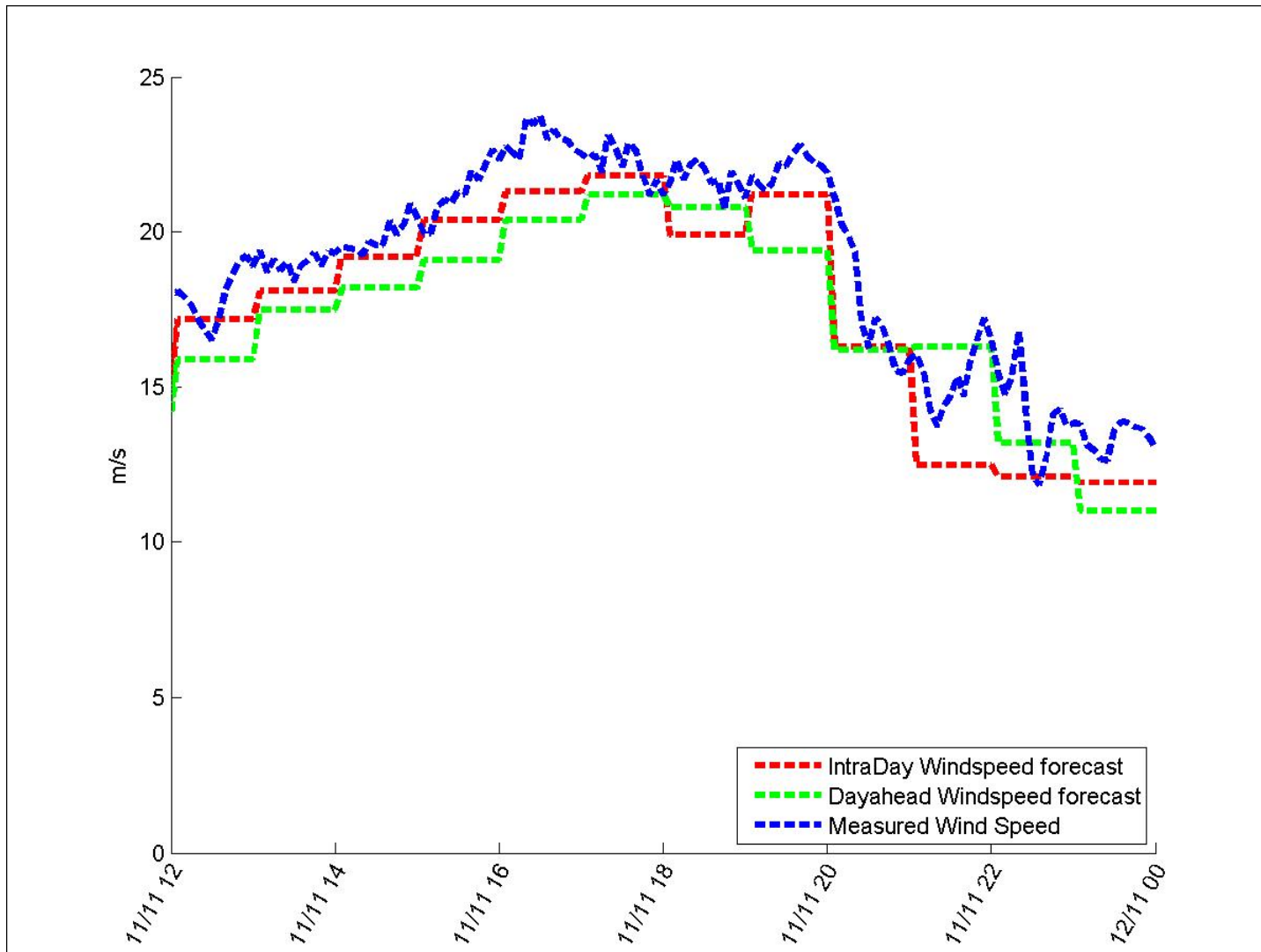
Wind speed – statistics of 91 wind turbines



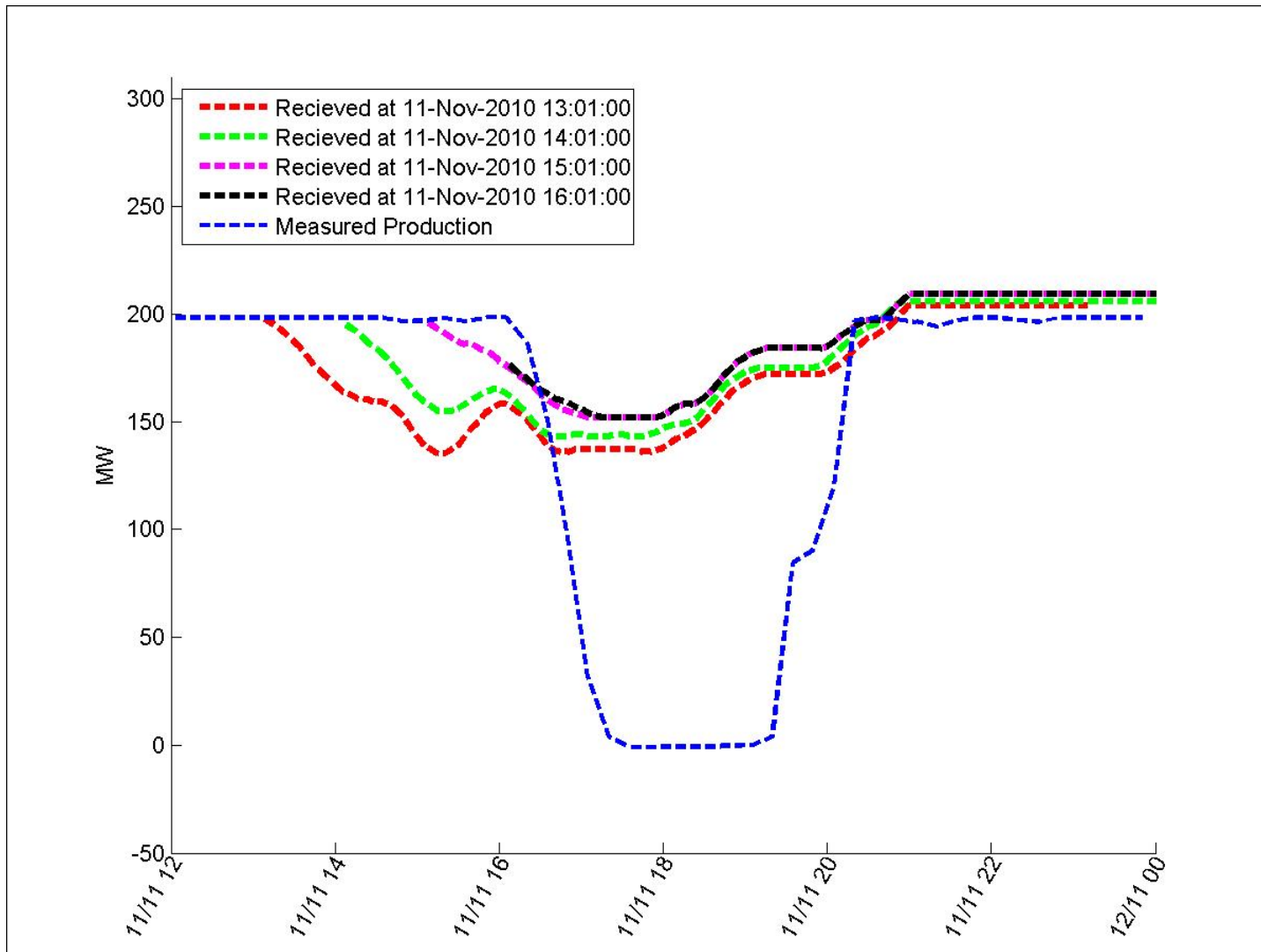
Wind power



Wind speed forecast

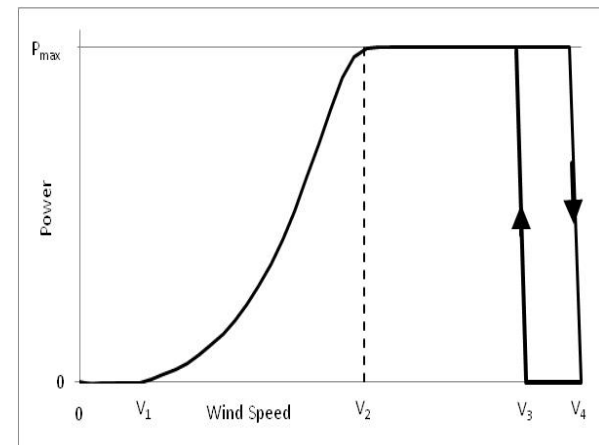


Wind power forecast



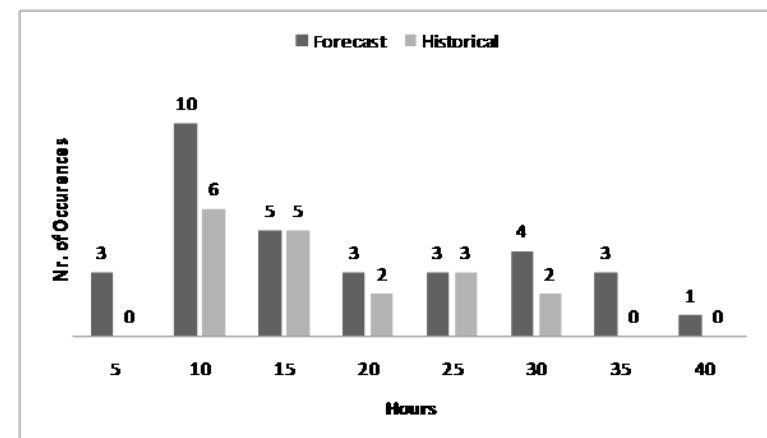
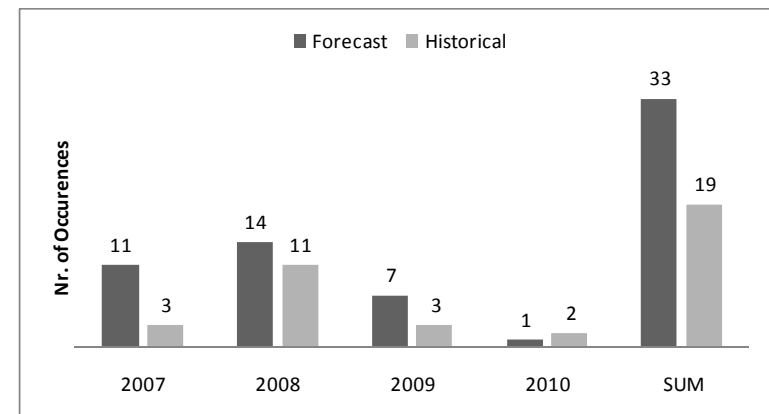
Definition of Extreme Wind Period (EWP)

- **Wind speeds:**
 - v_1 : cut-in wind speed
 - v_2 : rated wind speed
 - v_4 : cut-out wind speed
 - v_3 : high wind reconnection wind speed
- **EWP for single turbine**
 - Starts when $v > v_4$ (typically 25 m/s)
 - Ends when $v < v_3$ (typically 20 m/s)
- **EWP for wind power plant (wind farm)**
 - Starts when half of wind turbines are cut-out (typically at wind farm average 22.5 m/s)
 - Stops when half of wind turbines are re-connected (typically at wind farm average 18 m/s)



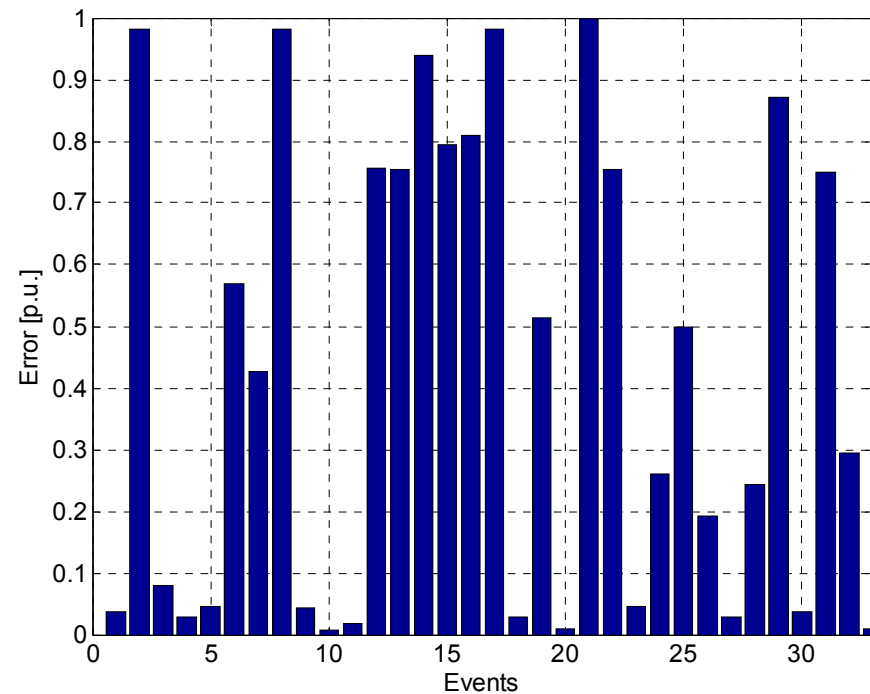
Statistics of Extreme Wind Periods (EWPs)

- Ideally, purpose is to compare actual and forecasted wind speeds
- Difficult to provide sufficiently long period of data
- Forecasts are from Energinet.dk
- Historical data would ideally be measurements, but are re-analysis performed with Weather Research and Forecasting (WRF)-model
- Graphs show 100m height (10m data much better agreement, but less relevant)



KPI: worst case forecast error

- Maximum absolute power prediction error for each Extreme Wind Period (EWP)



Conclusions

- New turbine controller will be developed
- Improved actions based on wind power forecasts will be developed
- Potential of Norwegian Hydro
- Impact from storm in Danish (UCTE) and Nordic system
- Correlation of storms in the regions will be assessed

THANK YOU FOR YOUR ATTENTION